

THE SCIENCE AND LAW OF OIL SHALE AND TAR SANDS DEVELOPMENT IN KENTUCKY*

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I. SELECTED SIGNIFICANT DATES

- 1541 Spanish Conquistador **DeSoto** travels through Western Kentucky
- 1694 English patent issued for “**Oyle from a kind of stone.**”
- 1719 Canadian Hudson Bay Company brought oil sand by Native Americans.
- 1751 **Christopher Gist** visits Big Bone Lick, Blue Lick and Drennon’s Lick in Kentucky.
- 1818 **Martin Beatty** brine well, drilled in McCreary County, Kentucky, produces oil.
- 1840 Canadian oil shale reported in Alberta, New Brunswick, Canada.
- 1854 Kentucky Geological Survey established.**
- 1859 Colonel E.L. Drake drills oil well “gusher” in Titusville, Pennsylvania.
- 1859 50 small shale oil extraction plants operate in Eastern United States
- 1865 Oil shale first mined in Australia
- 1872 United States Mining Law
- 1898 Oil pipeline from Monticello to Somerset, KY to Hamlen, West VA.
- 1901 Spindletop well in Beaumont, Texas produces oil gusher.
- 1911 **Standard Oil Company** broken up by United States Supreme Court.
- 1916 Oil well drilled near Irvine, Kentucky.
- 1917 Catlin Shale Products Company opens oil shale retort furnace, Elko Nevada.
- 1918 Swiss Oil Company (later **Ashland Oil**) chartered in Kentucky.
- 1920 United States Mineral Leasing Act
- 1925 **Floyd Collins** trapped in Sand Cave near Mammoth Cave in Kentucky.
- 1935 Interstate Oil and Gas Compact Commission (IOGCC) formed.**

* This seminar material is for instructional purposes only. Application to specific legal or factual issues necessitates a detailed analysis beyond that provided herein. Emphasis is added throughout to highlight the presentation. Statutory and regulatory provisions are selected for instructional purposes and are not inclusive of all potentially applicable provisions.

THIS IS AN ADVERTISEMENT

- 1957 Union Oil Furnace Co. opens shale oil plant, Parachute Creek, Colorado.
- 1960 Kentucky Division of Oil and Gas** established.
- 1960 Kentucky passes “Oil and Gas Conservation Act.” (KRS Chapter 353).
- 1961 Kentucky implements well plugging and abandonment regulations.
- 1962 Great Canadian Oil Sands Limited begins tar sands operation in Alberta, Canada.
- 1976 Federal Land Policy and Management Act (FLPMA).
- 1977 Massive hydraulic fracturing utilized at the DOE Eastern Gas Shales Project.
- 1978 Federal Natural Gas Policy Act
- 1980 **Addington Brothers** focus on Kentucky oil shale leases.
- 1980 Federal Crude Oil Windfall Tax Act
- 1981 1981 Eastern Oil Shale Symposium, Lexington, Kentucky.
- 1983 **Groundwater Protection Council (GWPC)** formed in Oklahoma
- 1987 Federal Oil and Gas Leasing Reform Act of 1987.
- 1989 Federal Natural Gas Well-head Decontrol Act
- 1992 Federal National Energy Policy Act
- 1997 **Slick-water fracturing** developed in Texas Barnett Shale by Mitchell Energy.
- 2004 Kentucky Revised Statute Chapter 349, dealing with **coal bed methane**.
- 2005 The Oil Shale, Tar Sands, and Other Strategic Unconventional Fuels Act of 2005.
- 2005 The Energy Policy Act of 2005**
- 2007 Kentucky passes “The Energy Incentives Development Act.”
- 2010 Original phase of **Keystone pipeline** from Alberta, Canada begins operating.
- 2011 **FracFocus** formed by GWPC and IOGCC.

II. UNCONVENTIONAL ENERGY SOURCES

- A. Shale gas
- B. Tight gas sands
- C. Coal bed methane
- D. Heavy oil tar sands
- E. Methane hydrates

III. SELECTED POTENTIAL “FRACKING” ENVIRONMENTAL ISSUES

- A. Potential drinking water aquifer contamination
- B. Use of available water resources for community and industry
- C. Land use issues (zoning)
- D. Greenhouse gas release, climate change and global warming
- E. Increased truck traffic on transportation infrastructure
- F. Chemical composition of fractionation fluids
- G. Earthquakes and seismic effects
- H. Technically Enhanced Naturally Occurring Radioactive Materials (TENR) or Naturally Occurring Radioactive Materials (NORM)
- I. Air pollution, including air toxics

- J. Contaminants in fractionation wastewater, including “flowback”
- K. Wastewater disposal, including underground injection
- L. Hydraulic fractionation water discharge, including brine
- M. Spill Prevention Control and Countermeasures (SPCC)
- N. Impact on aquatic habitats
- O. Stormwater discharges
- P. Well construction, casing and plugging
- Q. Impact of abandoned wells
- R. Environmental justice issues
- S. Resource sterilization

IV. SELECTED FEDERAL LAWS

- A. **Safe Drinking Water Act**, 42 U.S.C. Chapter 6A, Subchapter XII – Safety of Public Water Systems

- 1) **Regulation for State Programs**, 42 U.S.C. § 300h [See also the **Energy Policy Act of 2005**]...

“(d) **‘Underground injection’** defined; under-ground injection endangerment of drinking water sources

For purposes of this part:

- (1) **UNDERGROUND INJECTION.** – The term ‘underground injection’ –

- (A) means the subsurface emplacement of fluids by well injection; and

- (B) **excludes** –

- (i) the underground injection of natural gas for purposes of storage; and

- (ii) **the underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities.** [Emphasis added].

- (2) Underground injection endangers drinking water sources if such injection may result in the presence in

underground water which supplies or can reasonably be expected to supply any public water system of any contaminant, **and** if the presence of such contaminant may result in such system's not complying with any national primary drinking water regulation or may otherwise adversely affect the health of persons."

B. Federal Water Pollution Control Act

1. **Definitions, 33 U.S.C. § 1362**

"(24) **OIL AND GAS EXPLORATION AND PRODUCTION.** – The term '**oil and gas exploration, production, processing, or treatment operations or transmission facilities**' means all field activities or operations associated with exploration, production, processing, or treatment operations, or transmission facilities, including activities necessary to prepare a site for drilling and for the movement and placement of drilling equipment, whether or not such field activities or operations may be considered to be construction activities." [Emphasis added].

2. **National Pollutant Discharge Elimination System, 33 U.S.C. § 1342**

"(1) **Limitation on permit requirement...**

(2) **Stormwater runoff from oil, gas, and mining operations**

The Administrator **shall not require a permit** under this section, nor shall the Administrator directly or indirectly require any State to require a permit, for discharges of stormwater runoff from mining operations or **oil and gas exploration, production, processing, or treatment operations or transmission facilities**, composed entirely of flows which are from conveyances or systems of conveyances (including but not limited to pipes, conduits, ditches, and channels) used for collecting and conveying precipitation runoff and which are not contaminated by contact with, or do not come into contact with, any overburden, raw material, intermediate products, finished product, byproduct, or waste products located on the site of such operations." [Emphasis added].

C. Clean Air Act

1. **Hazardous Air Pollutants, 42 U.S.C. § 7412**

"(n) Other provisions

(4) **Oil and gas wells; pipeline facilities**

- (A) Notwithstanding the provisions of subsection (a) of this section, emissions from any **oil or gas exploration or production well** (with its associated equipment) and emissions from any pipeline compressor or pump station **shall not be aggregated** with emissions from other similar units, whether or not such units are in a contiguous area or under common control, to determine whether such units or stations are **major sources**, and in the case of any oil or gas exploration or production well (with its associated equipment), such emissions shall not be aggregated for any purpose under this section.
- (B) The Administrator **shall not list oil and gas production wells** (with its associated equipment) **as an area source category** under subsection (c) of this section, except that the Administrator may establish an area source category for oil and gas production wells located in any metropolitan statistical area or consolidated metropolitan statistical area with a population in excess of 1 million, if the Administrator determines that emissions of hazardous air pollutants from such wells present more than a negligible risk of adverse effects to public health.” [Emphasis added].

D. Orphaned, Abandoned, or Idled Wells on Federal Land, 42 U.S.C. § 15907

“(a) In general

The Secretary, in cooperation with the Secretary of Agriculture, shall establish a program not later than 1 year after August 8, 2005, to **remediate, reclaim, and close orphaned, abandoned, or idled oil and gas wells** located on land administered by the land management agencies within the Department of the Interior and the Department of Agriculture.”

V. SELECTED FEDERAL REGULATION

- A. **Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Review; Final Rule**; 40 CFR Parts 60 and 63; August 16, 2012, Federal Register, Volume 77, No. 159, Pgs. 49,490 et seq. [**But see industry and environmental group lawsuits**]
 - 1. NSPS Standard for VOCs
 - 2. New Source Performance Standard for Sulfur Dioxide
 - 3. Major Source Air Toxic Standard for Oil and Natural Gas Production
 - 4. Major Sources of Natural Gas Transmission and Storage Air Toxic Standard
- B. **EPA “Fracking Study”**
 - 1. **“Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources,”** in 2011.
 - 2. The final draft report is expected in 2014.

- C. **“Special Waste,”** including crude oil and natural gas exploration and development waste, is exempt from **Resource Conservation Recovery Act (RCRA)** hazardous waste rules. In 1978, EPA also exempted the category entitled **“oil and gas drilling muds and oil production brines.”** In 1980, the Solid Waste Disposal Act amendments included the **“Bentsen Amendment”** exempting **“drilling fluids, produced waters and other wastes associated with the exploration, development and production of crude oil or natural gas.”**

VI. SELECTED KENTUCKY STATUTES

A. KRS Chapter 353: Mineral Conservation and Development...

- .020 Oil and gas lease or contract, when lessor may avoid...
- .080 Drilling through coal bed.**
- .090 Gas found beneath or between coal beds.**
- .100 Casings to remain in place during life of productive well...
- .120 Method of plugging **well drilled through coal-bearing strata...**
- .140 Gas escape pipe, when to be used.
- .150 Unused oil, gas or **salt water well** to be closed to prevent waste.
- .160 Gas waste to be prevented – Presumption of negligence.
- .170 **Putting pressure on strata** – Wells may remain open if conforming to Federal Safe Drinking Water Act.
- .180 Requirements for plugging abandoned well – Bids – Remedy for possessor of adjacent land or for department...
- .200 Department for Natural Resources to enforce oil and gas law – Hearings...
- .400 Legislative declarations concerning availability and reliability of natural gas supplies – Construction of KRS 353.400 to 353.410...
- .630 **Pooling of oil and gas interests** – Conditions...
- .752 Kentucky Gas Pipeline Authority established – Membership...
- .802 Legislative findings and declarations relating to **geologic storage of carbon dioxide...**

B. KRS Chapter 349: Coalbed Methane Development

VII. SELECTED KENTUCKY REGULATIONS

A. 805 KAR Chapter 1 Division of Oil and Gas...

- 020 Protection of fresh water zones...**
- 060 Plugging wells; noncoal-bearing strata**
- 070 Plugging wells; coal-bearing strata**
- 080 **Gas storage reservoirs;** drilling, plugging in vicinity
- 100 Commission’s rules of procedure; spacing of deep well drilling; wildcat wells and pooling of interests
- 110 Underground injection control...**
- 130 Deep well administrative regulation relating to casing, cementing, plugging, gas detection and blow-out prevention
- 140 Directional and **horizontal wells...**

B. 805 KAR Chapter 9: Coal Bed Methane

- 010 Protection of fresh water zones...**
- 040 Plugging wells**
- 050 Gas storage reservoirs; drilling, plugging in vicinity...
- 070 Directional and **horizontal wells...**

C. 405 KAR Chapter 30: Oil Shale Operations...

- 110 Public participation in inspection and enforcement**
- 121 Oil shale exploration...**
- 170 Citizen demands for enforcement...
- 220 Postmining land use**
- 230 Air resources protection
- 240 Protection of fish, wildlife, and related environmental values...
- 260 Access roads, haul roads, overland conveyor systems, pipelines, and other transport facilities
- 270 Casing and sealing of drilled holes...**
- 300 Protection of the hydrologic system...**
- 320 Water quality standards, effluent limitations, and monitoring...
- 360 Waste management provisions...**

D. 401 KAR 5:090. Control of Water Pollution From Oil and Gas Facilities...

Section 5. Produced Water Disposal.

Section 6. Disposal of Produced Water Off the Facility...

Section 8. Surface Discharges of Produced Water...

Section 11. Disposal Wells...

Section 13. Spills and Leaks.

E. 401 KAR 10:031. Surface Water Standards...

Section 6. Pollutants. (1) Allowable instream concentrations of pollutants are listed in Table 1 of this section.

Table 1

Chloride (water quality criteria (mg/l)) – 250,000 (human health – DWS) – 1,200,000 (warm water aquatic habitat – acute) – 600,000 (warm water aquatic habitat – chronic)

VIII. GEOLOGY OF KENTUCKY

A. Stratigraphic Column (Kentucky Geological Survey, www.uky.edu/KGS.)

<u>Era</u>	<u>System and Series</u>	<u>Million Years Before Present</u>	<u>Resource</u>
Mesozoic	Cretaceous	144	Lignite?
	Jurassic	208	(not present in KY)
	Triassic	245	(not present in KY)
Paleozoic	Permian	286	(not present in KY)
	Carboniferous System		
	(Pennsylvanian)	320	Coal, oil, gas, sand
	(Mississippian)	360	Oil, gas, tar sand
	Devonian	408	Oil and gas
	Siluran	438	Oil and gas
	Ordovician	505	Oil and gas
	Cambrian	544	Oil and gas
Precambrian		4,500	Potential gas

B. Devonian life forms

1. **Continental Drift** - Gondwanaland under South Pole, Kentucky land mass forming as part of Laurasia at the Equator.
2. The **Devonian Period** expressed great evolution in fishes and aquatic life forms. The development of aquatic organisms able to crawl upon the land, was significant in the evolution of amphibians. The land surface itself, in areas which were to become Kentucky, were marshy, containing primitive plant life forms, including early insects.
3. There was a great, mass extinction of up to 70% of animal species at the end of the Devonian Period. The cause of the **mass extinction** is not certain. An interesting hypothesis relates to expanded vegetation on land increasing soil formation and rock weathering which, in turn, bound and removed carbon dioxide from the atmosphere. At the end of the Devonian Period, **sea levels dropped and glaciers appeared** in parts of Gondwanaland.
4. Animal groups:
 - a. Sponges
 - b. Brachiopods
 - c. Nautiloids
 - d. Agnathas
 - e. Chondrichthyes
 - f. Tetrapods
 - g. Scorpions
 - h. Amphibians
5. Plant groups:

- a. Fungi
 - b. Chlorophytes
 - c. Horsetails
 - d. Bryophytes
 - e. Lycopods
6. It is generally believed that Devonian Age shales are the **source rocks** for most of the oil and gas “plays” in Kentucky. An example would be the migration of heavy oils into the overlying tar sand deposits of the Mississippian Age near Western Kentucky’s Mammoth Cave in Edmonson County, Kentucky.

IX. KENTUCKY SHALE GAS AND TAR SANDS

A. Shale gas

1. Location (see maps)
2. Example (see handout samples and attached photograph)
3. Drilling method – (see maps)
 - a. hydraulic fracturing (“fracking”)
 - b. horizontal drilling
 - c. “fracking” materials
 - (1) fluids
 - (2) gases (including nitrogen gas in Kentucky)
 - (3) chemicals
 - (4) “proppants”
 - (5) diesel fuel (petroleum distillates)
 - d. In the **Marcellus Shale**, typical “frack” fluids contain approximately 99% water and sand (**proppant**). Additional chemicals make up the remaining 1% and could include **acid, antibacterial agent, breaker, corrosion inhibitor, friction reducer, gelling agent, iron control, scale inhibitor, and surfactant**. Depending on the shale field being drilled, additional additives such as **clay stabilizer, cross linker, non-demulsifier, and PH adjusting agent** might also be found.
 - e. **Proppants** include sand or ceramic beads to hold open fractures.
4. The “**Kick Off Point**” (**KOP**) is the area in a drilled well that begins the bend in the drilling to a horizontal plane. It can take six hundred feet to complete the bend. There are, on average, approximately 5,000 pounds per square inch of pressure placed in the fractionation well. Sand or tiny ceramic balls (**proppants**) are injected to prop open cracks related to the fractionation process. The horizontal wells can travel as far as 3,000 feet and are restricted, in part, by laws regarding property rights and “spacing.”
5. VOCs and methane, in addition to air toxics, can escape a well completion operation during that period of time known as “**flowback**.” During this time, reservoir gas, water, and fractionation fluids return to the surface at great volume and at high velocity. Such well completion period may last between three and ten days.

6. More than 5 million gallons can be used at a hydraulic fracturing well site and, mixed with sand (proppant) and chemicals, can be injected under as much pressure as 10,000 pounds per square inch.

B. Tar sands

1. Location – (see maps)
2. Example (see handout samples and attached photographs)
3. Heavy oil is found in tar sands in Western Kentucky (**Edmonson, Grayson, Butler, Warren, and Logan Counties**). In 2012, the **Arrakais Oil Recovery Company** announced a mining operation on 120 acres in Logan County. It could produce as many as 1,000 barrels of oil a day (42,000 gallons). The **Hart County Stone Co.** in Edmonson County, Kentucky also has plans to mine tar sands.
4. Kentucky's "**tar sands**" are not loose sands but are actually heavy oils trapped in the pores of solid sandstone rock, unlike the unconsolidated "**oil sands**" in Alberta, Canada.
5. There may be as many as **6 billion barrels of oil** in the Western Kentucky counties with tar sands. These heavy oils exist in Mississippi and Pennsylvanian rock formations at the edge of the **Eastern Interior Illinois Geologic Basin**. Some enhanced recovery techniques to retrieve this oil involve Direct Current (DC) to heat the heavy oils several hundred feet below the surface. Another technique of heavy oil extraction involves the use of Microwave Radiation to assist in their removal.

C. Data in Kentucky

1. There are approximately 26,500 **active oil wells** and approximately 7,900 **inactive oil wells** in Kentucky.
2. There are approximately 26,300 **active gas wells** and 3,600 **inactive gas wells** in Kentucky.
3. There are approximately 12,000 **abandoned oil and gas wells** in Kentucky that may not have been plugged, or may have had their steel casings removed.
4. There are approximately 3,400 Class II EPA **regulated underground injection (UIC) wells** in Kentucky.
5. Many oil and gas well logs are based upon readings of gamma ray radiation reflecting the presence of organic chemicals.
6. Many Kentucky oil and gas well logs are maintained in the core library of the Kentucky Geologic Society.
7. Kentucky's **deepest producing natural gas wells** are drilled into the Cambrian, Rome Formation exceeding 7,500 feet in depth.

X. KENTUCKY ENERGY AND ENVIRONMENTAL CABINET

A. Division of Oil and Gas

1. Director – **Kim Collings**
2. Assistant Director – Marvin Combs

3. Branch Office
 - a. Pikeville - Vacant
 - b. Barbourville – Jerry Finley
 - c. Madisonville – Cyrus Britt
 - d. Glasgow – Ron Norris
4. 22 People in Division

B. Oil and Gas Commission

1. D. Michael Wallen
2. Stephen Harris
3. Oliver Barber III
4. Oda Inglis

C. The Kentucky Division of Oil and Gas Mission is “... to regulate the crude oil and natural gas industry in the Commonwealth; protect the correlative rights of mineral owners, fresh water zones and mineral coal seams; and conserve and protect oil and gas reserves in Kentucky.” (Hydraulic Fracking in Kentucky, Kentucky Division of Oil and Gas).

D. The Kentucky Division of Oil and Gas states, in regards to horizontal drilling in Kentucky, that, “...operators in Kentucky have improved success in the Devonian shale when combining horizontal drilling with fracturing techniques involving nitrogen. Advantages: 1) reduces surface impact with multiple horizontal wells on a single well pad; 2) reduces negative impact on mining industry; 3) allows operator the ability to drill around surface/topographic features; 4) increases exposure to shale reservoir which increases reserve recovery.” (Hydraulic Fracking in Kentucky, Kentucky Division of Oil and Gas).

XI. OIL AND GAS AGENCIES AND ENTITIES

- A. **Kentucky Geological Survey**, James C. Cobb, State Geologist and Director, Lexington, Kentucky, 859-323-0559, established in 1854.
- B. **Kentucky Oil and Gas Association**, Andrew McNeill, Executive Director, Frankfort, Kentucky, 502-226-1955, formed in 1931.
- C. **The Interstate Oil and Gas Compact Commission (IOGCC)** was formed in 1935 as a multi-state government agency. Mike Smith, Executive Director, Oklahoma City, Oklahoma, 405-525-3592.
- D. **Kentucky Energy and Environment Cabinet, Department for Natural Resources, Oil and Gas Division**, Kim Collings, Director, Frankfort, Kentucky, 502-573-0147, established in 1960.
- E. **Groundwater Protection Council**, Mike Paque, Executive Director, Oklahoma City, Oklahoma, 405-516-4972, established in 1983 as a nonprofit corporation of state groundwater regulatory agencies.
- F. The Groundwater Protection Council and the Interstate Oil and Gas Compact Commission formed the **National Hydraulic Fracking Chemical Registry**, entitled FracFocus Chemical Disclosure Registry, www.fracfocus.org, in 2011. Companies voluntarily agree to post records relating to hydraulic fracturing activities as well as disclosure of chemical usage. Kentucky is not currently participating in the FracFocus system.

XII. UNDERGROUND INJECTION

- A. Underground Injection (UIC)
 - 1. EPA Class II Wells – oil and gas related injection wells
 - 2. Safe Drinking Water Act Regulations for UIC Class II Wells, 40 CFR Part 144
 - 3. Kentucky has for 2 years been seeking primacy for EPA’s Class II UIC well programs
 - 4. 805 KAR 1:110, **Kentucky underground injection regulations (awaiting primacy)**
- B. EPA regulated Class II wells. EPA regulates 168,069 such wells nationally (2011 data).
- C. Kentucky has 3,165 EPA regulated Class II wells.
- D. EPA Region IV UIC contact for Class II Wells – Jim Ferreira (404) 562-9399
- E. EPA does regulate the use of **diesel fuel in fracking operations** through the Underground Injection Control Program.

XIII. SELECTED DATA ON UNCONVENTIONAL SOURCES OF ENERGY

- A. **Kentucky**
 - 1. There are approximately ten permits for coal methane wells in Kentucky.
 - 2. In 2013, Kentucky Representative Gooch introduced a Bill in Kentucky Legislature to regulate remediation of oil and gas wells. (HB 348).
 - 3. In Kentucky, due to the presence of higher percentages of clay in the shale, hydraulic fracturing is not efficient. The swelling of the clay coming in contact with the frac water results in the sealing of the fractures. Kentucky has since the late 1980s used liquefied nitrogen gas in its fractionation processes.
 - 4. Around 2005, Eastern Kentucky gas fields began to be exploited using horizontal drilling techniques.
 - 5. Natural gas that is retrieved from Kentucky wells must have nitrogen gas removed in order to be placed in pipelines for transportation. New air pollution regulations recently promulgated by the EPA may impact the release of waste gases from these operations.
 - 6. During World War II, the need for additional steel during the war effort caused many abandoned wells in Kentucky to have their steel casings removed and recycled.
 - 7. Kentucky is a “capture” state which relates to the ownership and withdrawal of natural resources which can migrate in the subsurface.
 - 8. Kentucky oil formations are known as the 1) Big lime oil formation; 2) Brerea oil formation; 3) Devonian shale oil formation; 4) Corniferous oil formation.
 - 9. Kentucky has produced approximately 6 trillion cubic feet of natural gas since nitrogen fracking was introduced in Kentucky.
 - 10. Kentucky may have as many as 40,000 producing gas wells, mostly located in the Northeastern part of the state.
 - 11. As much as 174 quadrillion BTU remain in Kentucky in its total oil and gas resources.
 - 12. It costs between \$1.25 and \$3.5 million to drill a horizontal fractionation well in Kentucky.
 - 13. Ninety percent of gas produced in Kentucky is shipped elsewhere.

14. The New Albany Black Shale in Kentucky can produce 21 gallons of oil and 4,000 cubic feet of gas for each ton of rock processed. The New Albany Black Shale ranges in thickness from 100 feet near Louisville to greater than 800 feet below Pine Mountain, Kentucky.
15. There are approximately 18,000 producing oil wells and 13,000 producing gas wells in Kentucky. The state of Kentucky maintains a database which contains information on 136,286 wells in Kentucky. There are at least 1,500 known pools of oil and gas in the Kentucky subsurface. Oil is most often produced from Mississippi limestone and sandstone in the Western and Eastern portions of the state and from Ordovician limestone in the South Central portions of the state.

B. National

1. Controversial Communities

- a. Pavillion, Wyoming, Wind River Aquifer. In 2008, residents complained of odor, discolored water, and illness. Encana Corp., a natural gas company, operated in the area.
- b. Dimock, Pennsylvania, 2009. Methane and chemical contamination identified in 13 wells. Federal and state studies. Cabot Oil and Gas Corporation operated in the area.
- c. Raton Basin in Northern New Mexico and Southern Colorado (Trinidad). USGS investigation identifies increase in seismic activities possibly relating to underground injection of fracking waste.
- d. Oklahoma and Texas seismic activity is being investigated by the USGS, Oklahoma Geological Society and the University of Texas.

2. **New York State** does not currently allow hydraulic fracturing. New York State is currently under a hydraulic fracturing moratorium on shale gas drilling. This moratorium has been in place since 2008 and is the subject of much controversy in the state. It appears that the state government will not finish reviewing the issue until 2014.

3. Shale oil films and documentaries

- a. **Gasland**, 2010, Josh Fox, nominated for 2010 Academy Award for Best Documentary Feature. Expose on environmental problems with fracking. Picked up by HBO.
- b. **Truthland**, 2012, Independent Petroleum Association of America (IPAA) and Energy in America (EID); 34 minutes, viewable on "YouTube." A rebuttal to "Gasland".
- c. **Fracknation**, 2013, Phelim McAleer and Ann McElhinney. A rebuttal to "Gasland."
- d. **Promised Land**, 2012, Full length feature film starring Matt Damon. Plot involves obtaining mineral rights leases in Pennsylvania.
4. In the mid 1880s, Pennsylvania and Kentucky druggists sold oil from brine and gas wells as a medicine. The oils were marketed with such names as "Seneca Oil." "Kier's Petroleum or Rock Oil" was sold as **"nature's remedy celebrated for its wonderful curative powers, taken from a well 400 feet below the Earth's surface."**
5. **Kerogen** is the intermediate stage in the transformation of organic matter into petroleum. The transformation occurs first at low temperature (**diagenesis**) where oxygen, nitrogen and sulfur is released. Final

- transformation occurs at higher temperatures and pressures (**catagenesis**) with the ultimate result in methane gas and graphite.
6. Produced water, drilling mud, sludge, slimes, evaporation ponds and pits can contain **naturally occurring radioactive material (NORM)** from the rock and related soil. NORM can concentrate in mineral scales that form in pipes and also be present in other oil and gas wastes. Radium-226, radium-228, and radon gas may be present in some wastes. (See also KRS 211.863 and the Central Midwest Interstate Low-Level Radioactive Waste Commission.)
 7. The organic material in shale oil is considered to be predominantly the **decomposition of algae**, unlike coal, which has a higher proportion of vascular organic material.
 8. **The Marcellus Shale** covers an area approximately the size of the country of Greece and lies 6,000 feet below the surface of New York, Pennsylvania, West Virginia and Ohio.
 9. Approximately 11,500 existing wells are hydraulically fractionated annually.
 10. In the United States, there are 1.5 million miles of **natural gas pipeline**.
 11. There are approximately 1.2 million fractionated wells in the United States and approximately 100,000 with horizontal borings.
 12. **Hydraulic fractionation** has been used since the late 1940s in the Oklahoma and Texas region. Prior experiments removing gas from shale included the use of explosives.
 13. **Alberta, Canada** has abundant shale formations (the Duvernay, Montney, and Muskwa) which together may have more than 3,300 trillion cubic feet of natural gas, 58 billion barrels of gas liquids, and 425 billion barrels of oil.
 14. The **Green River formation** in the Western United States is the largest oil shale deposit in the world. It may contain 1.5 trillion U.S. barrels of oil in 213 billion tons of shale.
 15. The Governor of Nebraska has recently approved a rerouting of the **Keystone XL Oil Sands Pipeline** through less sensitive areas of the state, thereby avoiding the environmentally significant Sand Hills area. However, the pipeline will still cross the important Ogallala Aquifer.
 16. Much of the opposition to the **Keystone XL Pipeline** involves concern that utilization of Canadian tar sands and shale gas resources will increase greenhouse gas emissions and result in greater **climate change**.
 17. 100 years ago hydraulic fracturing was developed to break out granite blocks from production quarries.

XIV. SELECTED ENERGY AND ECONOMIC DATA

- A. **Mexico** has the fourth largest reserves of gas in the world. Remex, the Mexican oil company nationalized in 1938, has few oil shale wells and imports gas from the U.S.
- B. **China** has as much as twice the amount of recoverable oil shale gas than is found in the United States. Without development of its shale resources, China will import 50% of its natural gas by 2020.
- C. The low price of natural gas, and increased environmental regulation, has reduced the share of coal in the **American electrical power generation** market to less than 35% from greater than 50% ten years ago.

- D. In 2000, 5% of natural gas came from shale in the United States. In 2010, including tight gas and coal bed methane, that figure increased to 60%.
- E. By 2020, the United States' production of oil from shale should reach 10 mb/d (million barrels per day).
- F. **Natural gas derived liquids (NGLs)** are the basis of ethylene production, the basic building block of much of the petrochemical industry. With inexpensive gas being delivered in pipelines from the Northeast and the Gulf States, **Kentucky** is ideally situated to benefit from the shale gas revolution.
- G. American **steel industries** and **fertilizer industries** benefit significantly from abundant, inexpensive natural gas prices. There are approximately 10.2 billion cubic feet of natural gas passing through **Kentucky pipelines** every day. Pennsylvania and Ohio are producing more gas than can be used in the Northeast. Therefore, pipelines carrying natural gas in Kentucky may be reversed to deliver the natural gas supplies south. The **auto industry, aluminum industry, and chemical industry** in Kentucky stands to benefit greatly by the increased production of natural gas and the delivery of competitively priced supplies of natural gas from the Northeast.
- H. America's power and utility sectors are developing plans to reduce their dependence on coal and increase the utilization of abundant, inexpensive natural gas. **Coal to Gas Switching (C2G)** for fuel used by electrical utilities are driven by abundant gas supplies and historically low (decades) price. Environmental regulation may accelerate the closing of 60 gigawatts of coal based electricity generation by 2025.
- I. In 2010, natural gas hit 20-year lows below \$2.00/MMBTU (Henry Hub).
- J. United States Congressman Markey (D-Mass) proposed, in 2013, a bill entitled **"Keep American Natural Gas Here Act."** Political opposition, supported by U.S. industrial concerns, may result in a cap on the export of Liquid Natural Gas (LNG) from the U.S.
- K. **"Standard Producers AD8 Oil and Gas Lease Form"** is a standard form for oil, gas and mineral leasing.
- L. For gas drilling to be profitable in Kentucky, the price should be between \$4.00 and \$5.00 per million cubic feet. Recently as low as \$2.00, the price for natural gas has risen in the range of \$3.00 per million cubic feet but is expected to remain at these lower levels for an extended period of time.
- M. Electrical power generating plants that utilize coal as its fuel may see a closure of as much as 18% of the coal-fired capacity in the United States by the year 2020 because of abundant quantities of inexpensive natural gas and additional environmental air pollution regulations.
- N. Wet shale gas contains higher levels of **ethane and propane** as well as petroleum condensates which make the product more valuable. **Methane, propane and butane** are considered natural gas liquids.
- O. In **Pittsburgh**, because of lower natural gas prices, consuming utilities have fallen by more than 30% over the past three years.
- P. The **Keystone XL Pipeline**, when completed, is expected to carry 700,000 barrels per day of crude from Canada to the Gulf Coast refineries.
- Q. **Environmental groups** have filed suit against the EPA over its air pollution regulations for natural gas exploration, in part because the rule does not regulate methane, a potent greenhouse gas.
- R. Fixed costs for the production of 1 megawatt of electrical capacity is **\$90,000 for nuclear plants, \$30,000 for coal plants, and \$15,000 for gas plants.** The cost of fuel drives the economics of electrical generation and, with natural gas prices

- expected to remain low for decades, there will be pressure on utilities to move to natural gas and away from coal and nuclear for electrical generation.
- S. Internationally, the pace of shale gas development has been slowed due to the government ownership of mineral rights, lack of infrastructure and environmental concerns. There is also a lack of geologic data in much of the world's shale oil areas.
 - T. Abundant and inexpensive **ethane** is a primary feedstock for the chemical industry and is much cheaper than ethane produced from crude oil stocks.
 - U. **Methane** has 25 times the impact as a **greenhouse gas** than **carbon dioxide** but remains in the atmosphere for less than 10 years, whereas carbon dioxide can remain in the atmosphere for as long as 200 years.
 - V. **Germany** has decided, because of the nuclear accident in Japan, to retire its six nuclear electrical generating power plants by 2020. Germany was anticipating replacing that capacity with coal fired plants. However, it appears that Germany has at least 50 years of natural gas supplies in its oil shale resources which, if utilized, would be more cost-effective than coal and potentially reduce the impacts to global warming.

XV. MAPS AND PHOTOGRAPHS (SEE ATTACHED OR IN POWERPOINT SLIDE PRESENTATION)

1. Road Cut Oil Shale photograph
2. Kentucky Tar Sands Rock photograph
3. Physiographic Diagram of Kentucky (Kentucky Geological Survey, www.uky.edu/KGS).
4. Geologic Map of Kentucky - periods (Noger, USGS)
5. Kentucky Geologic Basins (May, modified from Noger, 1984)
6. Lower 48 States Shale Plays (Energy Information Service (EIA))
7. Gas production in conventional fields, lower 48 states (Energy Information Service (EIA))
8. Fuels map of Kentucky (Kentucky Geological Survey, www.uky.edu/KGS).
9. 2011 Kentucky gas well location (Kentucky Geological Survey, www.uky.edu/KGS).
10. Horizontal Wells in Kentucky (Kentucky Geological Survey, www.uky.edu/KGS).
11. North American Shale Plays (2011) (Energy Information Service (EIA))
12. Marcellus shale gas play, Appalachian Basin (Energy Information Service (EIA), USGS)
13. Generalized energy source cross section (Energy Information Service (EIA))
14. Hydraulic fracturing (Pro Publica, www.propublica.org/special/hydraulic-fracturing-national)
15. Kentucky Interstate Pipelines
16. Kentucky tar sands 2nd photograph
17. Principal areas of occurrence of tar sands in Kentucky (Kentucky Geological Survey, www.uky.edu/KGS)

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